

# **Atmospheric Plasma Depainting**

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# Overview

- Problem Statement
- Define Plasma
- Define Atmospheric Plasma
- Describe Atmospheric Plasma Coating Removal (APCR)
- Benefits of APCR
- Introduce the PlasmaFlux™ system
- Aerospace Depainting Efforts
- Navy Ship Depainting Efforts

# Problem Statement

- Annual cost of corrosion for DoD ~ \$20 Billion
- Virtually every weapon system across all segments of DoD require periodic maintenance of coating systems



Plastic Media Blasting



High Pressure Water Jet



Grit blasting

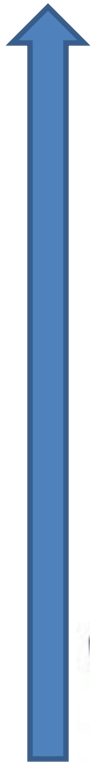
## Problem Statement, cont.

- Conventional media-based coating removal technologies generate large volumes of solid waste, are labor intensive, and hazardous to maintenance personnel.
  - High environmental impact
  - High cost of waste disposal
- Atmospheric Plasma Coating Removal (APCR) provides an environmentally benign and safe means of removing coatings and sealants.

# What is Plasma?

# Plasma: Fourth State of Matter

Increasing Energy



Solid



Liquid



Gas



Plasma



State of Matter

# What is Atmospheric Plasma?

# Plasma occurring at Atmospheric Pressure

Plasma in open air with  
no special chamber  
needed

Atmospheric Composition  
requires only compressed  
air as the feed-gas

# Atmospheric Plasma Coating Removal (APCR)



Atmospheric  
Plasma

+



Paint / Sealant

=



Carbon  
Dioxide



Water

- APCR requires no media
- Atmospheric plasma produces highly reactive gas
  - Cold plasma  $\Rightarrow$  high chemical energy, low thermal energy
  - Vaporizes organic portion of coatings to  $\text{CO}_2$  and  $\text{H}_2\text{O}$
  - No damage to temperature sensitive substrates

# Features and Benefits of APCR Technology

Feature	Benefit
No Media Required	Cost - Reduced procurement, storage, and disposal costs
	Safety - Reduced exposure to hazardous materials
	Environmental – Reduced environmental impact
Atmospheric Pressure Operation	Non-damaging removal, preserves surface profile
	Selective layer-by-layer removal
	Simple technology requires compressed air and electricity
	Safety – No special safety equipment or procedures
	Cost – Eliminates need for “hot work” zones, faster maintenance cycle
Compact size, low weight	Controlled manually or by robotics
	Reaches areas that are inaccessible to other technologies

# PlasmaFlux™ Technology

## Power Supply



## Plasma Source



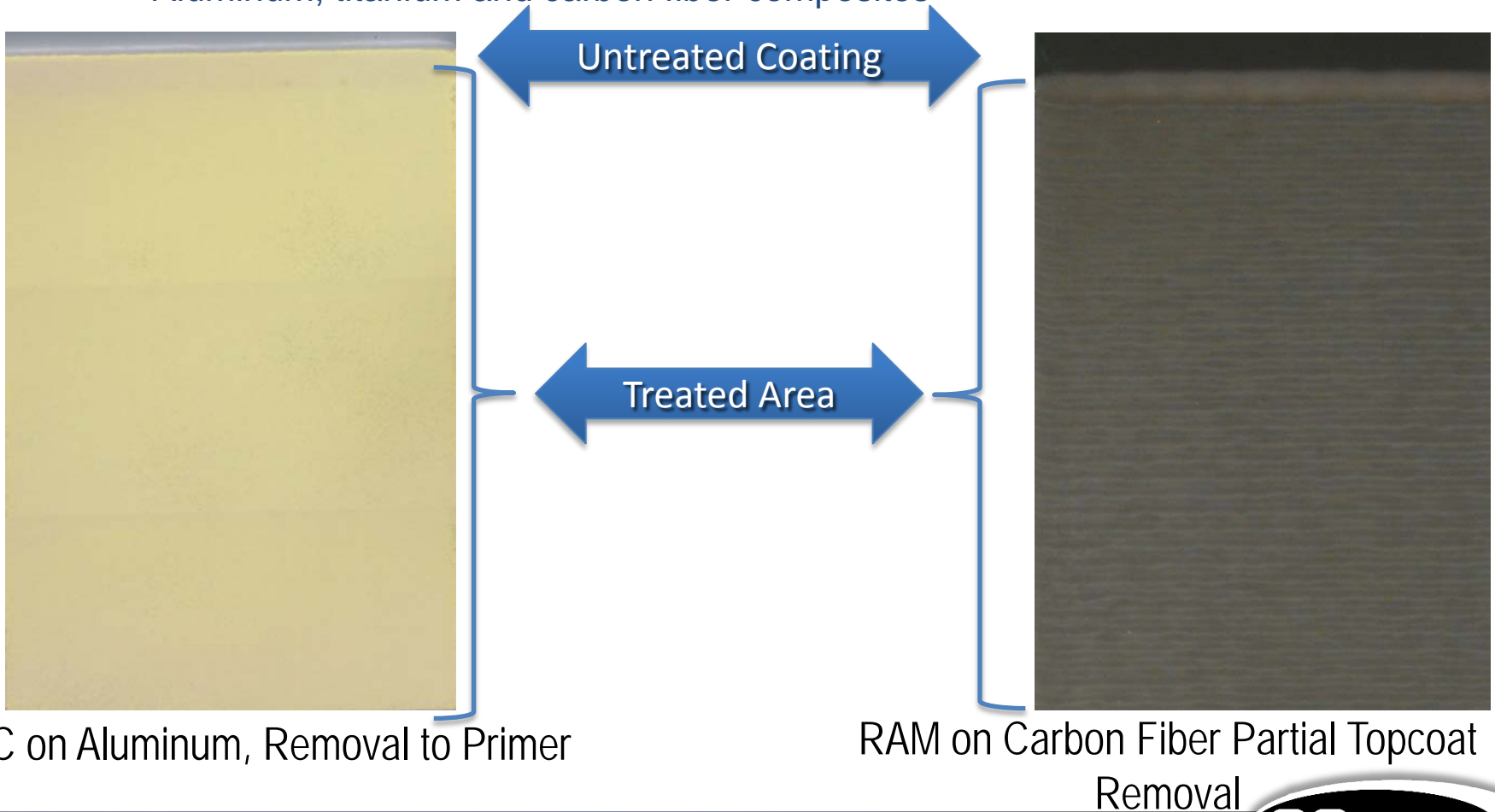
- The power supply produces a high frequency electric field to generate cold plasma
- Depot compatibility: Requires only compressed air and electrical power

# Aerospace Depainting Efforts

- APC (Advanced Performance Coating), RAM (Radar Absorbing Material), and Sealant removal
- Aluminum, Titanium, Composite substrates
- Accessing confined spaces where other technologies struggle

# Aerospace Coating Removal

- Selective layer-by-layer removal demonstrated on temperature sensitive substrates
  - Aluminum, titanium and carbon fiber composites



# Sealant Removal



- Rivets were initially covered with about 4 mm of sealant
- Rivets completely uncovered by hand held plasma pen

# Hand Held Removal of Polysulfide Sealant

AC-240-B2 Sealant (2-5 mm thick)  
applied to aluminum lap joint with  
protruding rivets



~15 second handheld removal  
around rivet leaving bare metal  
and powdery residue

# Aerospace Coating Removal Transition Programs

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- AFRL (WPAFB)
  - Evaluation of high power atmospheric plasma process for aircraft coating removal
  - Evaluation of handheld APCR for Sealant removal
- NAVAIR (Cherry Point)
  - Evaluate adhesion promotion of AP on surfaces
- Ongoing projects with prime contractors
  - Evaluating APCR for surface treatment of aircraft fasteners and sealant removal
  - Evaluating removal of specialty LO coatings on composite substrates

# Navy Ship Depainting Efforts

- Freeboard and anti-fouling Naval coatings

# Naval AP Depainting Development Programs

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- Navy Phase I & II SBIR (N00014-10-C-0266)
  - Projects focused on engineering development challenges
    - Power supply and plasma source designs
    - Improved single and multi-pen designs
    - Ruggedization for Dry-dock environment
    - Operation using Dry-dock 480V 3-phase power

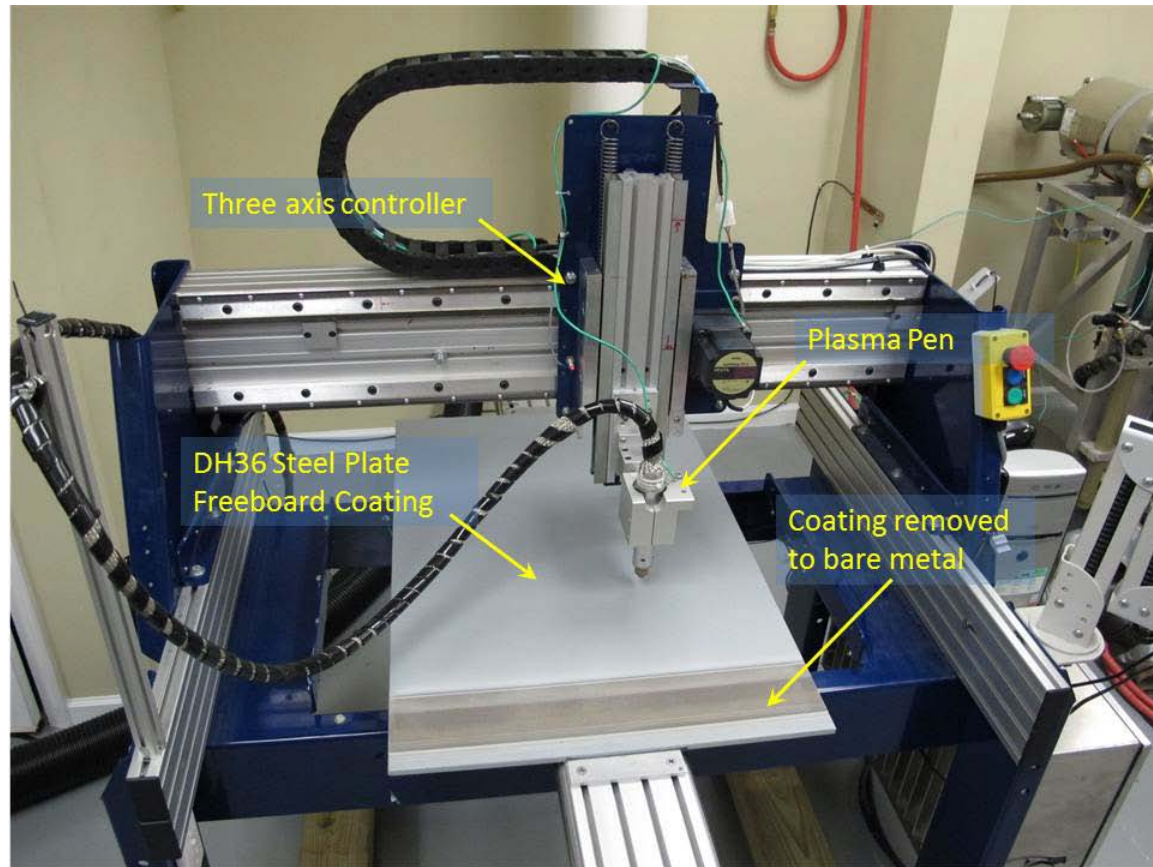
# Naval AP Depainting Development Programs

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- SERDP WP-1762
  - Recoating performance of APCR depainted surfaces
  - Multi-pen removal process development using SBIR designed plasma system
  - Removal rate enhancement on Naval ship coatings
  - Plasma plume-surface interaction
  - Environmental / Health characterization of the plasma depaint process

# Naval Coatings Removal

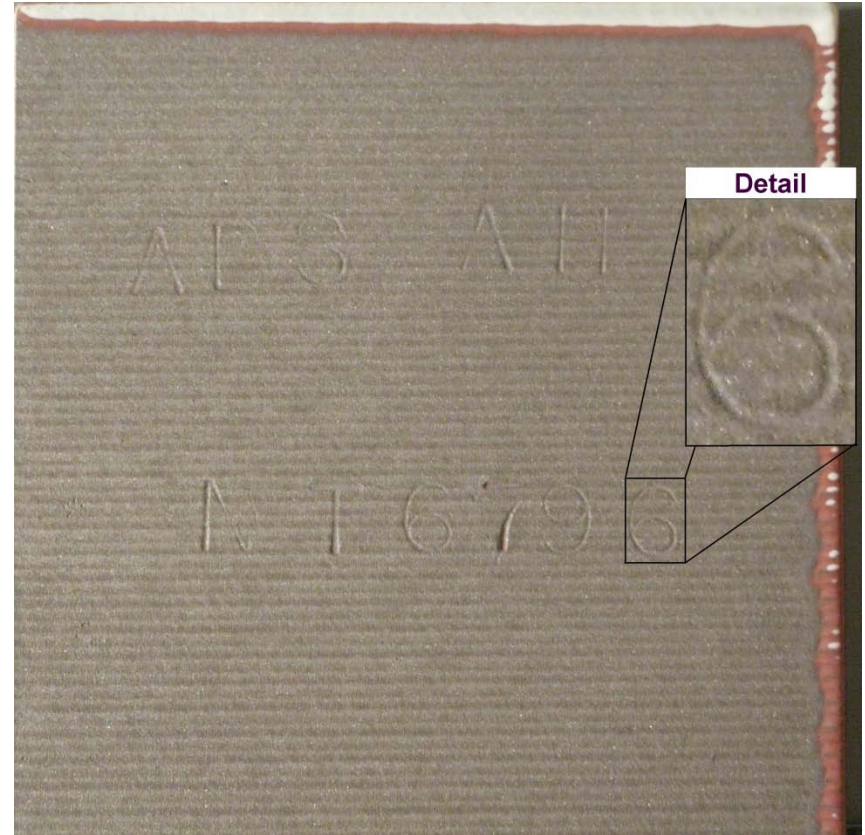
- Plasma pen integrates with COTS automated system for coating removal tests
- Sample coupons
  - 24" x 36" 3/8" DH36 steel
  - ( $\pm 2.5$  mil roughness)
- Coating stacks
  - Freeboard
  - Anti-Fouling
  - 20 mils thick (nominal)



Three axis automated system

# Anti-Fouling Coating Removal

- APCR produces surface with “near white metal blast cleanliness”
- Underlying surface profile is unchanged
- Uniform removal demonstrated for freeboard and anti-fouling coatings
- Demonstrated excellent adhesion of re-applied coating



# SERDP Program Findings So Far

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- Comparable efficacy of APCR to conventional Naval coating removal techniques
- Test panels were depainted by grit blasting and APCR to “near white metal” conditions and then repainted
- No significant performance difference of reapplied coatings was observed between APCR and grit blast surface preparation
  - No discernible difference in surface grain size, structure, or composition.
  - Pull-off adhesion tests of re-applied coating are comparable
  - No significant coating performance difference in salt fog and cathodic disbondment testing

# Technology Transition

- Scale up plasma coating removal technology to production rates
  - Increased power levels (power source and plasma pen)
  - Multiple plasma pens
- Ruggedize power supply and pen for testing under depot conditions
  - Outdoor marine environment: Category III, Pollution Degree 4
  - Compliance standards taken into consideration in design



Four Pen Array

# Special Thanks

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- AFRL: Jeff Kingsley, Natasha Voevodin
- ONR: Stephen McElvany
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- SERDP: Bruce Sartwell

# Thank You

Atmospheric Plasma Solutions, Inc.

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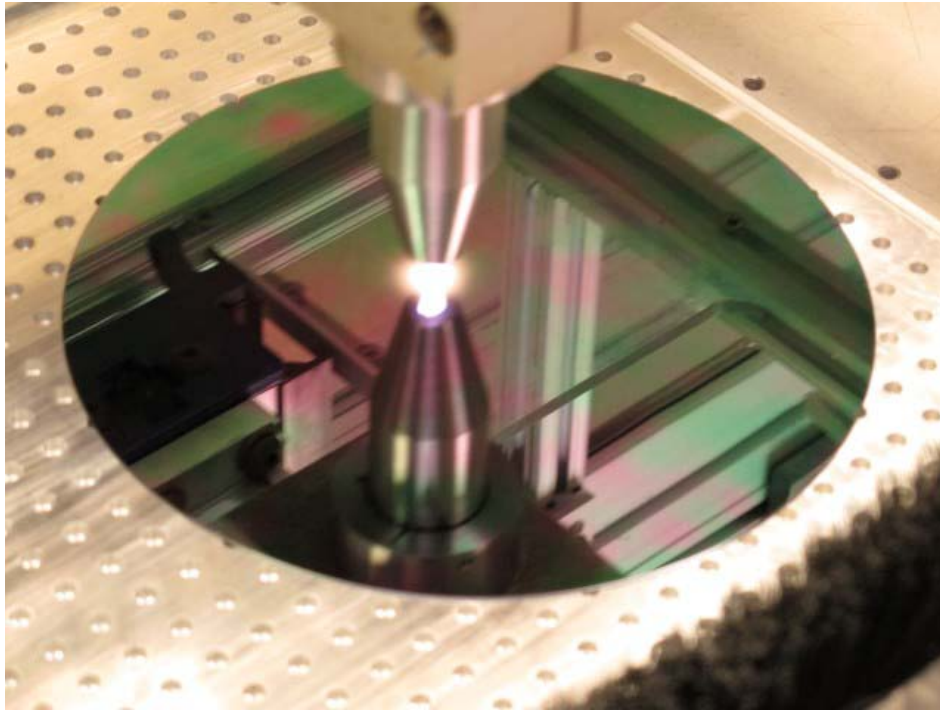
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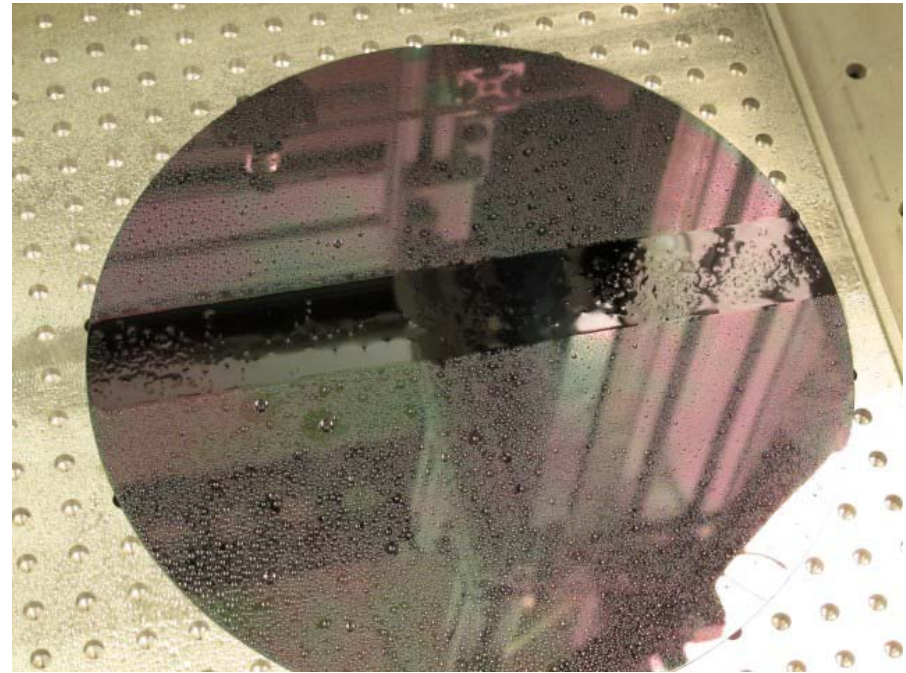


# Additional Slides

# Surface Energy Enhancement, Adhesion Promotion



1 second linear sweep across silicon wafer surface



Produces extremely hydrophilic,  
high surface energy path